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(54) Synchronizing arrangement for a planetary gear.

(57) In a planetary gear (1) witn an axially displaceable ring wheel (24), which can be coupled together with coupling rings (10,19) on either side of the planetary gear (1), synchronization rings (16,23) are arranged with external locking teeth. The ring wheel (24) is designed at its axial ends with a number of recesses (30), each accommodating locking bodies (31) which are spring-loaded in the radial direction and which bear against the synchronization rings (16,23) and which, during gear change movements, come to bear against shoulders (38) on the synchronization rings (16,23) in order to transmit axial force action to the synchronization ring (16,23) in question.

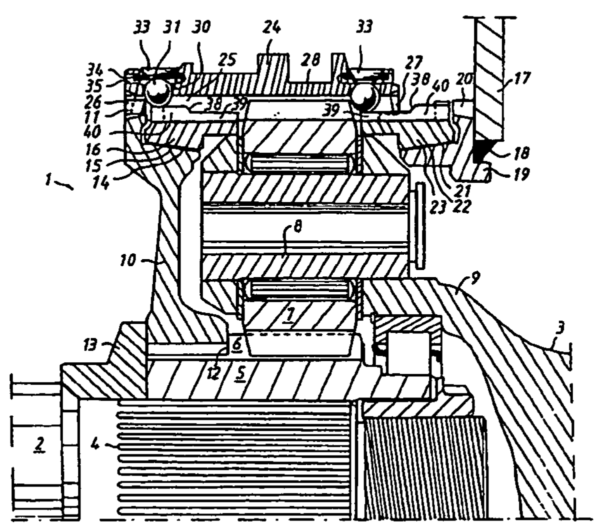

FIG 1

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SYNCHRONIZATION ARRANGEMENT FOR A PLANETARY GEAR

The present invention relates to a synchronization arrangement in accordance with the preamble of attached Patent Claim 1.

In transmission systems for heavy-duty vehicles, for example lorries, it is known to connect a supplementary gearbox to the main gearbox of the vehicle for the purpose of doubling the number of gear change possibilities. Such a supplementary gearbox usually comprises a planetary gear, by means of which the gear change possibilities of the drive unit can be divided into a low gear range and a high gear range. In the low gear range use is made of gear changing in the planetary gear, while in the high gear range no gear changing takes place in the planetary gear.

It is also known to design such planetary gears with synchronization arrangements for the purpose of facilitating gear changing during running. The positioning of the synchronization arrangements and the coupling members necessary for the gear change manoeuvring may vary.

In one embodiment, which is advantageous from the point of view of power distribution, the ring wheel of the planetary gear constitutes a coupling muff which, by means of axial displacement, can be brought into engagement with coupling rings on axially either side of the planetary gear. An embodiment of this type is described in greater detail in Swedish Patent Specification SE 453,379 (and corresponding specifications US 4,821,591 and EP 0,239,555).

In this embodiment, a number of tangentially directed springs effect a rotation, limited relative to the ring wheel, of the synchronization rings in such a way that locking teeth arranged on these assume, during a synchronization phase, a position which locks the gear movement.

In contrast, when synchronous rotation has been achieved, it is possible, under the counteraction of the springs, to turn the synchronization rings and move the ring wheel/coupling sleeve axially for coupling together with a coupling ring.

One disadvantage of this embodiment is that the springs act only in one direction, and as a result of this a predetermined direction of rotation is assumed. When the planetary gear is used as illustrated as a supplementary gearbox, this means that synchronization is only possible when driving forwards and, therefore, not when reversing. The possibilities of using a planetary gear of this type in other applications are limited, for example in a gearbox consisting of several planetary gears with alternating directions of rotation. This known planetary gear is also disadvantageous from the manufacturing and assembly point of view, which also means that it is a relatively expensive solution.

Patent Application SE 7807692-4 describes another embodiment in which each of the synchronization rings is connected to a plate collar designed with axial, resilient tongues. These tongues engage in internal circumferential grooves in the ring wheel and are intended, on the one hand, to connect the ring wheel to the respective synchronization ring with a locking effect and, on the other hand, to dampen relative vibratory movements between the ring wheel and the synchronization rings. The formation of grooves in the ring wheel encroaches on its cog tracks, which must therefore be made correspondingly larger in the axial direction, and this means that the dimensions of the whole transmission increase in the axial direction.

Patent Specification DE 1,750,546 describes another embodiment in which the synchronization rings are designed with a number of radial shoulders engaging recesses formed for this purpose on the inside of the ring wheel. By means of designing the recesses with a longer extent than the shoulders in the peripheral direction, the synchronization rings are afforded a certain possibility of rotation relative to the ring wheel. However, no further details are given on how this relative rotation possibility takes place. The formation of the internal recesses in the ring wheel limits the ring wheel cogs to a corresponding extent. In order to ensure engagement between ring wheel and planet wheels under all circumstances, the recesses must be positioned at a sufficient distance axially from the planet wheels. This results in the ring wheel having a long axial extent.

In both the abovementioned embodiments the ring wheel can be connected to the output shaft in order to obtain direct gear. This is disadvantageous from the point of view of power distribution since the gear is then subjected internally to high forces.

The aim of the present invention is to provide a synchronization arrangement for a planetary gear which does not have the abovementioned disadvantages of the known solutions. The invention therefore relates to a planetary gear which is advantageous from the point of view of power distribution, permits a short axial length, permits synchronized gear changing independently of the direction of rotation, permits simple and inexpensive manufacture and assembly and also prevents gear changing from being carried out completely before synchronous running has been obtained. These aims are achieved according to the invention by virtue of the fact that the planetary gear is designed with the features mentioned in attached Patent Claim 1.

By means of arranging the locking bodies according to the invention in recesses in the ring wheel, it is possible, during gear movements, to obtain an axial power transmission from the ring wheel to the synchronization ring in question, which is then turned in a manner known per se in such a way that its locking teeth prevent gear movement until synchronous rotation has been obtained. The machining necessary to form the recesses is simple and can be carried out at low cost in conventional machine tools. Similarly, the components included are of simple design, which all in all means that the whole arrangement is inexpensive. By virtue of the fact that the recesses are formed directly in the ring wheel, no extra space is required either in the axial or radial direction, which means that the whole planetary gear can be made compact.

Further features and advantages of the invention will emerge from the following illustrative description of an advantageous embodiment of the invention. In the description, reference is made to the attached drawings, in which

Figure 1 shows an axial longitudinal section of a planetary gear according to the invention,

Figure 2 shows a diagrammatic view of cooperating coupling teeth for synchronization and coupling, and

Figure 3 shows a radial partial section of the ring wheel of the planetary gear.

A planetary gear 1 according to the invention is illustrated here by a supplementary gearbox intended to be connected to a main gearbox in a heavy-duty vehicle, such as a lorry or a bus. The supplementary gearbox comprises a gearbox housing accommodating the planetary gear 1, which is arranged between an input shaft 2 from the main gearbox and an output shaft 3 from the supplementary gearbox.

A sun wheel 5 forming part of the planetary gear 1 is arranged on the input shaft 2 in a rotationally fixed manner by moans of spline connections 4, this sun wheel 5 being designed with external teeth 6 which engage in five surrounding planet wheels 7. Each planet wheel 7 is mounted on a tubular axle spindle 8 connected to a planet wheel carrier 9. This planet wheel carrier 9 is integral with the output shaft 3 of the planetary gear 1. A coupling ring 10 which is designed with external coupling teeth 11 is also arranged in a rotationally fixed manner on the sun wheel 5 by means of teeth engagement. The coupling ring 10 is positioned axially to the sun wheel 5 between a bevelled edge 12 of the sun wheel 5 and a support ring 13 arranged on the input shaft 2. The coupling ring 10 is also designed with a radially outward-directed conical friction surface 14 which is designed to cooperate with a corresponding inward-directed conical friction surface 15 on a synchronization ring 16.

The gearbox housing consists of two halves and in the dividing plane between them there is secured, by means of a number of guide pins and bolt connections, an annular reaction plate 17 which is designed with a centre hole. At the said centre hole a coupling ring 19 designed with external coupling teeth 20 is arranged by means of a weld connection 18. The coupling ring 19 is also designed with an outward-directed conical friction surface 21 which is designed to cooperate with a corresponding inward-directed conical friction surface 22 on a synchronization ring 23. This synchronization ring 23 is designed identical to the previously mentioned synchronization ring 16, these synchronization rings 16,23 being arranged in the gearbox in a mirror image relative to each other axially on either side of the planet wheels 7. These are surrounded in a conventional manner by a ring wheel 24 which is designed with internal teeth 25 engaging in the planet wheels 7. In addition, the ring wheel 24 is designed with internal coupling teeth 26,27 at its axial ends, which are designed to cooperate with the coupling teeth 11,20 of the coupling rings 10,19. It is advantageous if, as is shown in Figure 2, the coupling teeth 26,27 and the teeth 25 of the ring wheel 24 are integral with each other.

The ring wheel 24 is mounted displaceable in the axial direction relative to the planet wheels 7. The ring wheel 24 is designed on the outside with an annular groove 28 in which a coupling fork (not shown) engages in order to give the ring wheel 24 an axial displacement during gear changing. The ring wheel 24 is also designed at each of its axial ends with an even number of recesses, for example twelve, which are here illustrated as radial holes 30 which are distributed in pairs at uniform angles around the periphery of the ring wheel 24, as shown in Figure 3. Each hole 30 accommodates a locking body, advantageously in the form of a ball 31. Each ball 31 is pressed radially inwards under the action of a spring member. In this example, the spring member is an essentially tangentially-directed plate spring 33, which at its respective ends bears against two balls 31 lying close to each other. The plate spring 33 is secured at its middle by means of an axial key 34 accommodated in an axial hole 35 arranged for this purpose in the ring wheel 24. In this example, in which there are twelve balls 31 at each end of the ring wheel 24, there are therefore six plate springs 33 at each end of the ring wheel 24.

As also emerges from Figure 3, the holes 31 in the ring wheel 24 are oriented in the centre of the tooth apertures 36. In addition, the holes 30 are designed with a bottom 32 which holds the balls 31 in the respective hole 30, but which nevertheless

allows part of the respective ball 31 to project out into the corresponding tooth aperture 36. At the tooth apertures 36, which in this way are designed with balls 31, the two synchronization rings 16,23 are designed with axially extending bars 37. However, these bars 37 have a narrower profile shape than the respective tooth aperture 36, and this means that the synchronization rings 16,23 can move relative to the ring wheel 24 with a certain rotatable play.

In the radial direction, the respective bars 37 of the synchronization rings 16,23 have a shoulder 38 which divides an axially inner part 39 from an axially outer part 40. As can be seen in Figure 1, the inner part 39 has a smaller radius than the outer part 40. In the mounted state, as seen in Figure 1, the balls 31 bear under the action of the plate spring 33 against the bars 37 of each synchronization ring 16,23. The balls 31 on the right-hand side bear against the inner part 39 of the right-hand synchronization ring 23, while the balls 31 on the left-hand side bear against the outer part 40 of the left-hand synchronization ring 16.

The synchronization rings 16,23 are moreover designed with external locking teeth 41,42 which, during the synchronization procedure, in a conventional manner lock the gear-change movement until synchronous rotation has been achieved. The locking teeth 41,42 have a pointed shape at their axial surfaces facing towards the ring wheel 24 and are designed with oblique edges 43,44, but otherwise have the same profile shape as the internal tooth apertures 36 of the ring wheel 24.

The function of the planetary gear 1 described is as follows. Figures 1 and 2 show the planetary gear 1 with its high gear range engaged. The left-hand coupling teeth 26 of the ring wheel 24 engage with the coupling teeth 11 on the left-hand coupling ring 10, the ring wheel 24 being coupled in a rotationally fixed manner to the sun wheel 5 and the input shaft 2. The output shaft 3 thus comes to rotate at the same speed as the input shaft 2. When engaging the low gear range of the planetary gear 1, the ring wheel 24 is displaced axially by means of the coupling fork engaging in the groove 28. In Figures 1 and 2, this displacement is effected to the right. Assuming that the change of gear from the high gear range to the low gear range is carried out during running, in the high gear range the ring wheel 24 rotates at a certain speed, while the right-hand coupling ring 19, which is connected in a fixed manner to the gearbox housing, does not rotate.

Before the low gear range can be engaged, the rotation of the ring wheel 24 must be braked. In the high gear range the rotation of the ring wheel 24 is assumed to have a direction corresponding to an upward movement in Figure 2. Upon displacement of the ring wheel 24 towards the right in Figure 2, after a certain displacement the coupling teeth 26 of the ring wheel 24 on the left-hand side are disengaged from the left-hand coupling ring 10 and, thus, disengaged from the input shaft 2. At the same time the balls 31 on the right-hand side of the ring wheel 24, which during the start of the gear-change process bear against the inner part 39 of the respective bar 37 of the right-hand synchronization ring 23, come to bear against the respective shoulder 38 on the synchronization ring 23. In this way the ring wheel 24 exerts via the balls 31 an axial force on the synchronization ring 23, which results in its conical friction surface 22 coming to bear in a sliding manner against the corresponding friction surface 21 on the right-hand coupling ring 29. The synchronization ring 23 is thus subjected to a braking moment, which means that it is turned relative to the ring wheel 24 to a position in which the locking teeth 42 on same block the continued axial displacement of the ring wheel 24. When the coupling teeth 27 of the ring wheel 24 come to bear in this way in a locking manner against the locking teeth 42 of the synchronization ring 23, the ring wheel 24 is also subjected to a braking moment.

After synchronous rotation has been achieved or, as is the matter under consideration here, the rotation of the ring wheel 24 has been braked completely, the axial force which the coupling teeth 27 of the ring wheel 24 exert on the bevelled side surfaces 43,44 of the locking teeth 42 is sufficient to turn the ring wheel 24 to a position in which the locking teeth 42 fit into the tooth apertures 36 of the ring wheel 24 and no longer prevent the axial movement of the ring wheel 24. The ring wheel 24 can thus be axially displaced to engage with the coupling ring 19 and is coupled together in a rotationally fixed manner with the gearbox housing. The low gear range of the planetary gear 1 is thus engaged and achieves in a manner known per se a gear change between the input shaft 2 and the output shaft 3.

The change from the low gear range back to the high gear range is effected in an analogous manner by means of the ring wheel 24 being displaced towards the left in Figures 1 and 2. If the gear change takes place during running, it is necessary to accelerate the ring wheel 24 to the same rotational speed as the input shaft 2. Similarly to what is stated above, it is assumed that the input shaft 2 rotates in a direction which in Figure 2 corresponds to an upward movement. Thus, in the low gear range, the left-hand coupling ring 10 rotates, while the ring wheel 24 does not rotate. When the ring wheel 24 is displaced towards the left, the locking teeth 41 of the left-hand synchronization ring 16 lock the displacement of the ring

wheel 24 until synchronous rotation has been achieved. During the initial stage of the synchronization procedure, the balls 31 on the left-hand side of the ring wheel 24 bear against the corresponding shoulder 38, with the result that the synchronization ring 16, by means of a sliding bearing between the friction surfaces 14,15 of the synchronization ring 16 and the coupling ring 10, is subjected to a moment which twists the synchronization ring 16 into a locking position.

After synchronous rotation has been achieved, the synchronization ring 16 and the ring wheel 24 rotate at the same speed as the coupling ring 10. The synchronization ring 16 can in this way be turned relative to the ring wheel 24 into a non-locking position which allows the ring wheel 24 to be axially displaced and coupled to the coupling ring 10.

The moments which, during the gear change procedure, act on the two synchronization rings 16,23 are always directed in the same direction for each synchronization ring 16,23 provided that the direction of rotation of the input shaft 2 is always the same. This is the case when driving forwards. In contrast, when reversing, the input shaft 2 rotates in the opposite direction, and the directions of rotation described are thus reversed.

In order to permit synchronized gear changing both when driving forwards and backwards, it is necessary for the oblique edges 43,44 of the locking teeth 41,42 to be designed symmetrical, and as shown in attached Figure 2. In alternative embodiments of the invention, where synchronization is only required in one direction of rotation, it is possible to use locking teeth whose edges 43,44 are designed asymmetrical.

The planetary gear 1 according to the invention is advantageous from the manufacturing point of view. The necessary machining of the ring wheel 24 can be carried out easily in conventional machine tools. Likewise, the assembly is simple and allows the ring wheel 24 to be completely pre-assembled with balls 31 and plate springs 33 before the planetary gear 1 is assembled. The design according to the invention means that the space requirement of the planetary gear in the axial direction is small, and in the radial direction no extra space is required. Moreover, the design of the planetary gear 1 according to the invention means that the conical friction surfaces 15,22 and 14,21 respectively on the synchronization rings 16,23 and coupling rings 10,19 respectively can be arranged at a great radial distance from the input and output shafts 2,3. This means that the moments, which are caused during the synchronization procedure by the friction forces, can attain high values. This in turn means that the dimensions of the friction surfaces 14,15,21,22, particularly in the axial direction, can be kept within low values and that the whole gearbox can be designed relatively short.

The invention can also be modified within the scope of the following patent claims and can be designed other than has been described in the above example.

Thus, the range of use of the planetary gear according to the invention is not limited to that of a supplementary gearbox, but instead it can also be used in other types of gearboxes, for example hydraulic automatic transmissions where a number of planetary gears are coupled together to each other. Similarly, the invention can be used in other configurations of coupling possibilities between the planetary gear parts and the input and output shafts of the gearbox and the gearbox housing.

Furthermore, the invention can also be used in those synchronization arrangements in which there are a number of synchronization rings on either side of the planetary gear.

Claims

1. Synchronization arrangement for a planetary gear (1) comprising an axially displaceable ring wheel (24), two coupling rings (10,19) arranged on either side of the planetary gear (1) and with which the ring wheel (24) can be coupled together alternately in order to achieve different gear positions, and at least two synchronization rings (16,23) arranged between each coupling ring (10,19) and the planetary gear (1), which synchronization rings (16,23) are, on the one hand, designed to be rotatable in a limited manner relative to the ring wheel (24) and, on the other hand, are designed with external locking teeth (41,42) which, during the gear change movement, lock the axial displacement of the ring wheel (24) and the coupling together to the coupling ring in question (10,19) until synchronous rotation is present, characterized in that a number of recesses (30) are arranged at both axial ends of the ring wheel (24), each recess accommodating a locking body (31), in that spring members (33) are designed to act radially inwards on the locking bodies (31) so that they bear against the respective synchronization ring (16,23), and in that each synchronization ring (16,23) is designed with a radial shoulder (38) against which each of the locking bodies (31) bears during the axial displacement movement of the ring wheel (24) towards each synchronization ring (16,23) in order to transmit an axial force from the ring wheel (24) to the synchronization ring (16,23) and in this way to establish contact between friction surfaces (14,15, 21,22) on the synchronization ring (16,23) and the coupling ring (10,19).

2. Synchronization arrangement according to Pat-

ent Claim 1, characterized in that the locking bodies are designed as balls (31).

3. Synchronization arrangement according to Patent Claim 1, characterized in that the spring members are designed as plate springs (33) extending tangentially between two recesses (30) lying close to each other, in that each plate spring (33) is secured at its middle on the ring wheel (24), and in that each plate spring (33) at its respective ends bears against a locking body (31).

4. Synchronization arrangement according to Patent Claim 1, characterized in that the recesses (30) are arranged at tooth apertures (36) in the ring wheel (24), and in that the synchronization rings (16,23) at these tooth apertures (36) are designed with axial bars (37) engaging with rotatable play in the respective tooth aperture (36).

5. Synchronization arrangement according to Patent Claim 4, characterized in that the locking bodies (31) bear against each of the bars (37) on the synchronization rings (16,23).

6. Synchronization arrangement according to Patent Claim 4, characterized in that the shoulders (38) are designed in bars (37) of the synchronization rings (16,23) between an axially inner part (39) and an axially outer part (40) on each bar (37).

7. Synchronization arrangement according to Patent Claim 4, characterized in that each of the recesses is designed as a radial hole (30) in the ring wheel (24) and is designed with a bottom (32) which prevents the locking body (31) from being pressed completely out of the respective hole (30).

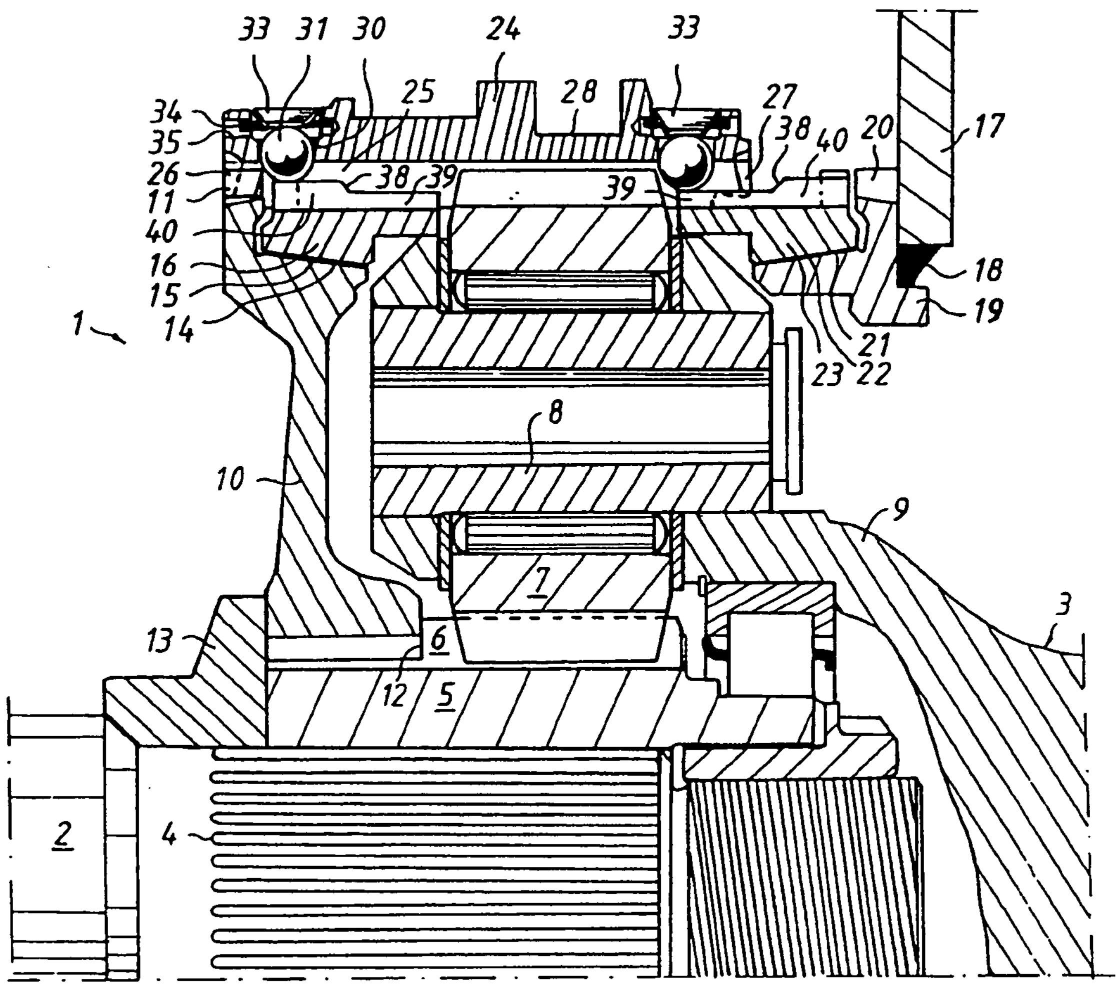
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FIG 1

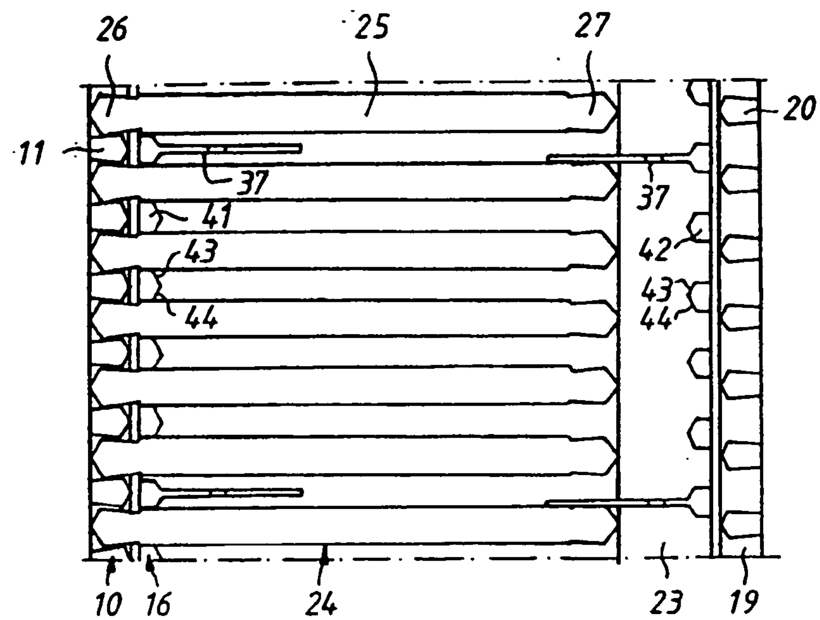

FIG 2

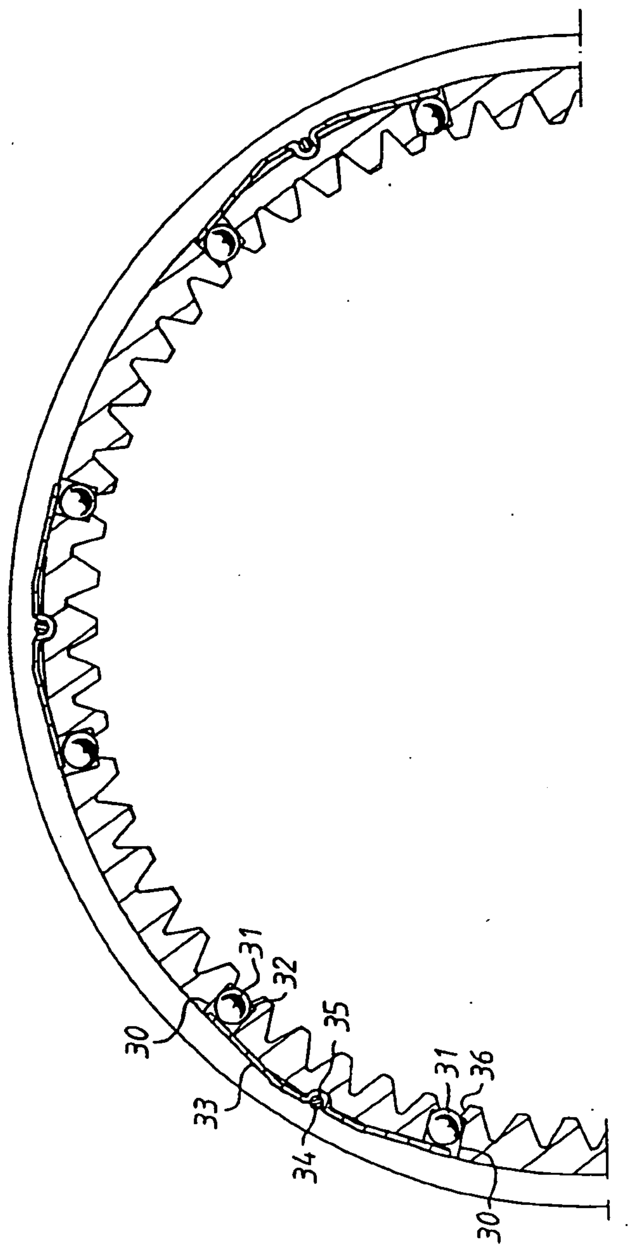

FIG 3

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EUROPEAN SEARCH REPORT

Application Number

EP 90 20 2619

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,Y	DE-A-1 750 546 (ZAHNRADFABRIK FRIEDRICHSHAFEN) * Whole document * – – –	1	F 16 H 3/78 F 16 D 23/06
Y	DE-A-3 225 201 (VOLKSWAGENWERK) * Whole document * – – –	1	
Y	US-A-3 543 897 (LEMKE) * Whole document * – – –	1-3,6	
Y	FR-A-2 268 986 (ZAHNRADFABRIK FRIEDRICHSHAFEN) * Whole document * – – –	1-3,6	
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A	US-A-2 221 892 (ORR) * Whole document * – – –	1,2,7	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	GB-A-1 204 855 (ROOTES) * Whole document * – – – – –	1-3	F 16 H 3/00 F 16 D 23/00

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	23 January 91	BALDWIN D.R.

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